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INTEGRATED INFORMATION PROCESSING/COMMUNICATIONS: THE KEY TO CO--ETC(U)
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The essay begins with the observation that sensor/surveillance, targeting, and command and control systems are proliferating at unprecedented rates. Similar concurrent growth in communications capabilities, on which tactical automated systems rely, has not taken place. The key to successful employment of tactical automated systems generate and the author argues that the use of packet radio technology is the best way to satisfy this requirement. He argues further that the solution to the special needs

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of the RDJTF is through the use of a combined satellite/packet radio network. The major thrust of the paper is that the technology is now at hand to field an integrated radio capability to provide the near real-time network connectivity of data systems needed on the extended battle field and that we must capitalize on this availability.

US ARMY WAR COLLEGE

INDIVIDUAL RESEARCH BASED ESSAY

INTEGRATED INFORMATION PROCESSING/COMMUNICATIONS: THE KEY TO COMMAND, CONTROL AND INTELLIGENCE ON THE EXTENDED BATTLEFIELD

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26 APRIL 1982

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INTRODUCTION

Over the past six years the United States Army has twice revised "FM 100-5: Operations," the doctrinal bible which tells us not only what we must do to win on the contemporary battlefield, but also how we ought to do it. In what can only be described as an appropriate and welcome process, we see in these revisions a refined blending of the traditional principles of war with revised concepts for modern combat. The purpose of these revisions has been, of course, to outline how best to counter the current and foreseeable challenges of well-equipped hostile forces which employ Soviet-style doctrine and tactics. In the edition of FM 100-5 published in 1976, doctrinal thought contained therein focused on the European scenario and called for the employment of active defense tactics and massive firepower to stop a Soviet attack on NATO countries. The current version of FM 100-5, published in final draft in September 1981, exhibits a shift to a more positive view of the purpose of military operations, i.e., not simply to avert defeat but, rather, to gain victory. To accomplish this objective, FM 100-5 establishes the dual requirements that U.S. combat power be fully integrated on the battlefield, and that the battlefield be "extended" to the full depth of attacking enemy formations.[1]

The concept of integrated and extended operations implies dynamic battlefield activity characterized by initiative, depth, agility and synchronization.[2] Each of these characteristics, in turn, implies the

availability of, and reliance on, solid communications for its presence in support of the operational concept. To exercise initiative we must learn of opportunities quickly, decide and then rapidly issue directives or requests to our forces to capitalize on them. Communications is required! Depth on the battlefield implies long-range surveillance, dispersion of friendly forces, and, more importantly, extension of our influence over wide areas by command and control of those dispersed units. Depth on the battlefield cannot occur without communications! To survive and to succeed, we must avoid enemy strengths and attack enemy weaknesses in a repeated manner so as to keep him off balance. Communications provides timely information on the fast moving battlefield to permit this agility of action! Finally, synchronization of dispersed combat forces in order to obtain maximum combined effect at a specific place and/or time can only be accomplished through communications!

THE COMMUNICATIONS REQUIREMENT

In the introduction the general need for solid communications to interconnect the extended battlefield was stressed. It is an absolute requirement without which we shall have great difficulty in making the extended battlefield concept serve our purpose! General Donn A. Starry, in an article published in 1981 while he was commander of the US Army Training and Doctrine Command (TRADOC), expressed the broad communications support requirement in more specific terms. "Key," in his view, "to a credible war-fighting capability on an integrated battlefield are:

- o Sensor/surveillance systems to prevent surprise attack in peacetime and provide necessary targeting/surveillance in wartime.
- o Command control (systems) sufficient to integrate all - source intelligence in near-real time in peacetime and in wartime, and to provide that intelligence and targeting information to maneuver force employments in near-real time as well."[3]

By analyzing and expanding on General Starry's statement of requirements, we can deduce the more specific characteristics which communications support on the extended battlefield must exhibit. First, we must recognize that sensor/surveillance, targeting and command and control systems are proliferating at unprecedented rates. Figure 1.

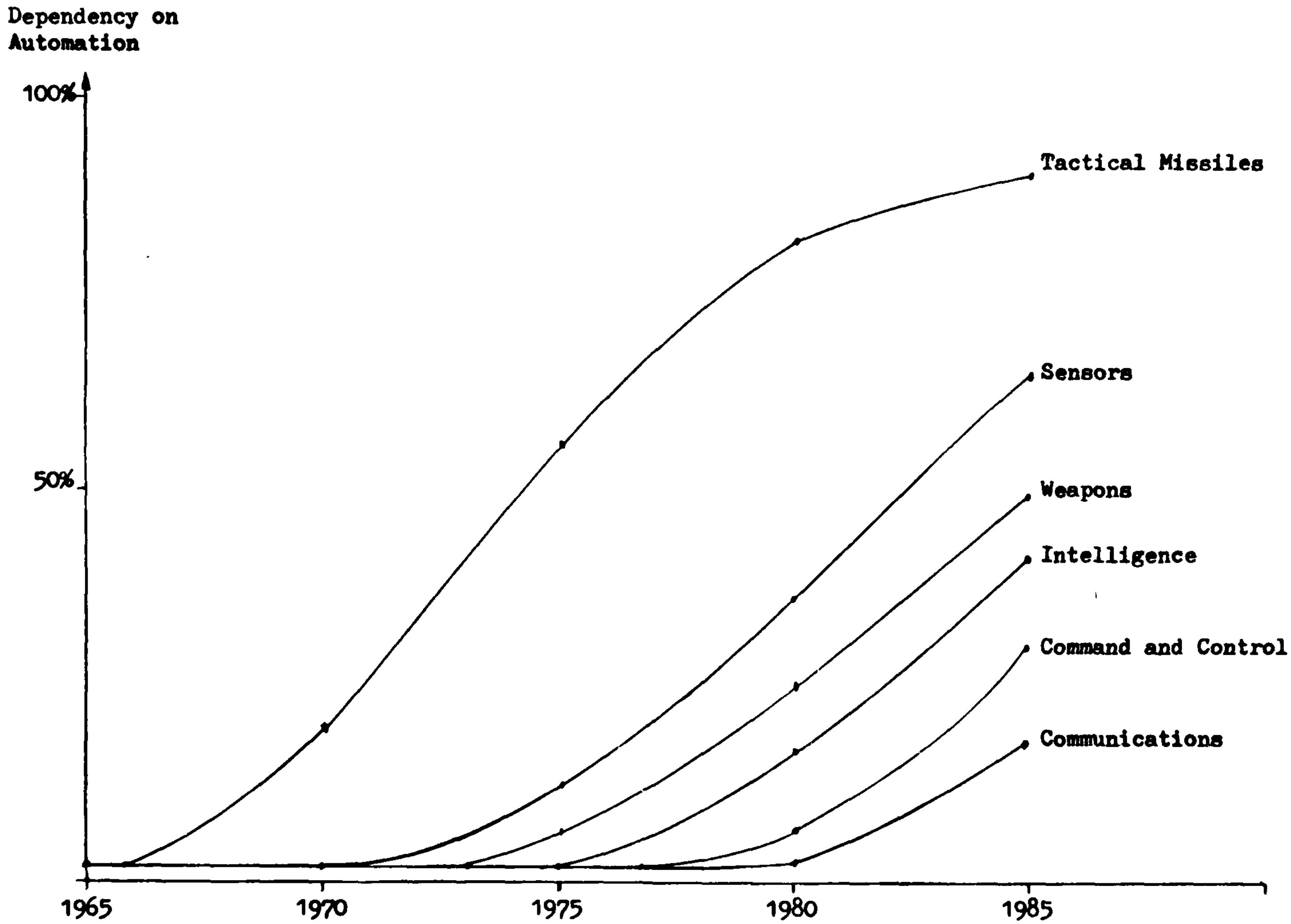

Figure 1. Graphical Comparison of the Growth of Battlefield Automated Systems in the U.S. Army[4]

demonstrates graphically the history of automation growth in tactical Army systems for various functional areas through 1985. All of these systems involve the collection, processing and exchange of large volumes of battlefield information which is converted to digital form for ease of transfer, handling and manipulation by computer. To cite but a single example, the Tactical Fire Direction System (TACFIRE) being issued to our field artillery formations is an automated, digital system.

Second, communications support for these systems on the dynamic, constantly changing extended battlefield will have to be provided almost exclusively by radio means. What's more, the need for "near-real time" information exchange, as specifically called for by General Starry, dictates not only that radio be the medium used but that it be radio capable of high-speed, low error transmission.

Finally, communication systems supporting tactical automated systems need to be automated themselves. Referring again to Figure 1., two points stand out. Automation of tactical functions is increasing significantly! Communications displays the least growth! The latter point is particularly disturbing when it is realized the communications is the system on which the others so heavily rely!

In addition to exhibiting the characteristics outlined above, communications systems for tactical automated systems support must possess a high degree of survivability; they must be lightweight, rugged and as mobile as the headquarters they service on the modern battlefield; they must be reliable and provide for redundant network connectivity. Automating the communications systems themselves allows the essential systems management function to be exercised with speed, accuracy and flexibility. With computer power in the system, the management function may also be distributed throughout the system. This, in turn, averts

the possibility of catastrophic collapse of the system because of a combat loss of one or several key communications nodal points. Survivability and redundancy are therefore significantly enhanced by requiring that communications systems have the capability to spread the technical management function within the networks they provide.

JUSTIFICATION OF THE REQUIREMENT

In order to appreciate the urgent need for a tactical communications capability to distribute data efficiently on an extended battlefield, it is useful to review recent experience in this regard. In an article titled "Covering Force Operations," Colonel Robert E. Wagner describes exercise operations and problems encountered by his 2d Armored Cavalry Regiment in Germany. The article is considered relevant because the size of force compares favorably with the "close combat force" (approximately a reinforced brigade) envisioned for maneuver use on the extended battlefield. The article was selected also because of the routinely dynamic nature of the cavalry regiment's operations and the close approximation of those operations to the combat activity to be expected on the extended battlefield. Typical examples would be: short notice moves, frequent changes in direction, rapid identification of, and reaction to, unforeseen threats. Significantly, Colonel Wagner reported that controlling his widely dispersed subordinate units "taxed the communications capability of the 2d Cavalry to the limit." He further indicated that better communications equipment is sorely needed and that timely, i.e., near-real time, combat information and reaction are essential to success on the extended battlefield.[5] Clearly, the VHF-FM radios organic to his regiment as the primary means of mobile communications lack the range and flexibility to support extended operations. We must remember this is the situation <u>before</u> the regiment is equipped with

tactical automated systems input/output (I/O) devices!

Two tactical automated systems, Tactical Operations System (TOS) and TACFIRE, were designed and engineered in the 1970s with the intent that both would operate over existing VHF-FM radio equipment. Although the system has not been deployed to the field, an analysis in May 1980 of the proposed TOS showed that severe systems management problems and delays could be expected due to overburdened FM radio nets. It further indicated that these problems are exacerbated when retransmission stations are used, as they frequently are, to extend the range of FM nets.[6] TACFIRE has been produced and deployed in quantity to field artillery line units. The system has also undergone extensive testing at Fort Sill, Oklahoma. Unfortunately, testing experience there has shown that current VHF-FM radio equipment injects unacceptable delays (upwards of 1/2 minute on the average) into fire support operations in intense combat conditions. Test results point once again to the range inadequacy of current VHF-FM radios as well as to the delay and retransmission problems highlighted in the TOS analysis.[7] The net effect is reduced combat support effectiveness from TACFIRE, a modern automated system constrained to operate over radio equipment designed in the 1950s.

Clearly, the key to successful employment of the tactical automated systems we envision lies in providing a capability for near-real time distribution of the data these systems generate. Without such an upgraded communications capability, the new sensor/surveillance, targeting and command and control systems, when taken as a whole, may actually hinder our effectiveness in fighting on the extended battlefield.

USE OF PACKET RADIO TECHNOLOGY TO SATISFY REQUIREMENTS

Earlier in this essay we showed that the US Army is actively pursuing the automation of tactical functions which heretofore were almost exclusively manual operations. The key combat functions, i.e., maneuver, fire support, intelligence, air defense and combat service support, are all involved in this ongoing effort. Different data systems are under development in each functional area. There nevertheless is a thread of commonality in these systems in that they are all computer-based digital data systems. Such systems require connectivity among and between themselves in sporadic time sequences. Computer-based system communications are thus said to be "bursty", or of low network utilization, since the time intervals between short segments of transmitted data are comparatively long. Additionally, these systems have the common feature that they are generally deployed on the battlefield in a layered, overlapping fashion with collocation of system components frequently occurring. While certain components of the intelligence system, for example, sensors, might be deployed further forward than the I/O devices of the combat service support system, overlap of these systems would occur from battalion-level rearward. As another example of systems layering, components of the air defense system would be widely spread among all areas of the extended battlefield and would overlap all the other automated systems in terms of physical deployment. The similarity of the technical characteristics of these systems and the

relatively close collocation of their component parts on the battlefield simplifies to a certain degree the problem of supporting these systems with interconnecting communications.

There are essentially two fundamental and competing approaches to providing the communications required. The more familiar technique is the one we've utilized for years, namely, dedicated, sole-user communications for each and every requirement which can demonstrate the priority to justify the full-time committment of communications assets. Justifications are usually couched in terms of need for speed and rapid response. In a Corps or Division Tactical Operations Center, we still see banks of telephones and teletypewriters, each one terminating an essential point-to-point link to some other headquarters. Not a very efficient use of resources when one reflects on the quantity of communications gear which must be committed, transported, operated and maintained is support of such ventures! The other technique departs from the sole-user approach and embraces the concept of dynamic allocation of communications means. The advent and rapid advance of computer technology is the enabling force in this second technique which, for reasons which will soon come clear, is referred to as "packet" communications.

In the second technique, messages to be transmitted over a data network are first assembled in one or more blocks of data called packets. Typically, a packet consists of a preamble of network control information bits followed by necessary addressing information and the collection of data bits to be transmitted. Once presented to the communications network, each packet is switched along the network as an entity from origin to destination under processor control in the net-

work's nodal points. If, for example, a single message requires two or more packets to cover in total the data to be sent, the packets will be forwarded individually from the origin and reconstituted at the destination before presentation to the addressee. By capitalizing on the "bursty" characteristic of data systems communications, the packet switching technique is able to make far more efficient use of transmission resources.[8] When the packet switching technique is combined with net-type radio communications, we have the integrated communications/information processing capability which is required for effective combat operations on the extended battlefield. Figure 2. depicts a sample Packet Radio (PR) Network deployed in support of an hypothetical Army force. For ease of explanation, only a representative portion of the complete network is shown. Illustrated in the figure are the following transmission/communications capabilities examples:

- o Digital I/O device to digital I/O device, as in the segment #1 to #3.
- o Sensor to digital I/O device, as in the segment #2 to #3.
- o Sensor to computer, as in the multi-radio hop segment #2 to #9 to #10 to #5 to #13.
- o Computer to Computer, as in the segment #11 to #6 to #5 to #13.
- o Digital I/O device to computer, as in the segment #4 to #8 to #10 to #6 to #12.

From the list of capabilities above, we see that PR networks provide total flexibility of connectivity on the battlefield. PR networks provide a high throughput, low delay means of interconnection for users, many of whom will be mobile. PR terminals and relay nodes are "smart", having their own micro-processors to control the internal operation of

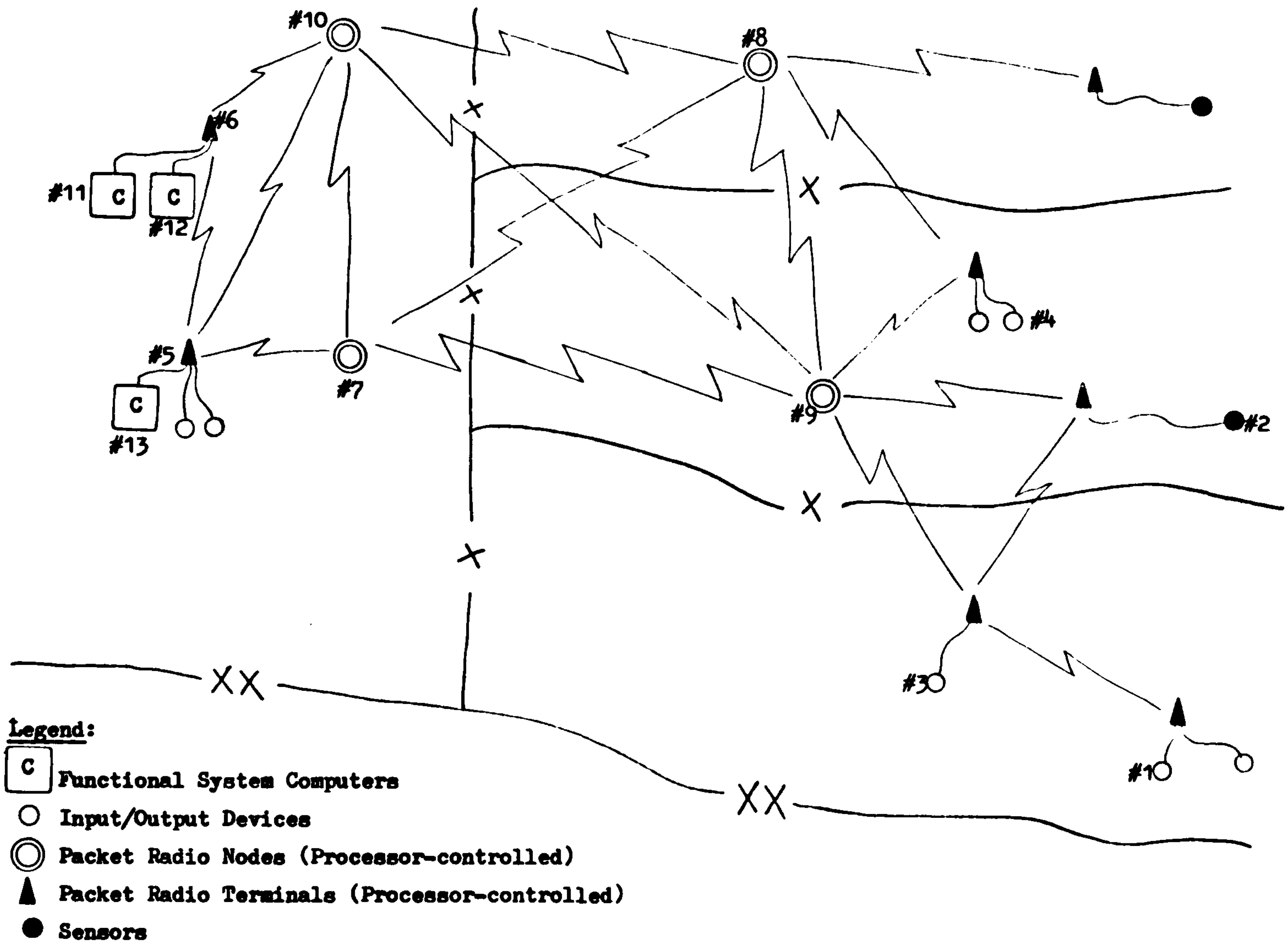

Figure 2. Diagrammatic Representation of a Portion of a Deployed Packet Radio Network

the network. This capability allows the PR network to adapt itself to all manner of network conditions while maintaining a transparent interface with network users. Data delivered to the user is totally unaffected by the process of getting it to its destination. PR networks afford the capability for users of tactical functional systems to interoperate with those systems while on the move. Area coverage with full network connectivity provides this capability. PR networks are fast. With 100 kilobits/second signalling rates on the radio links, near-real time transfer of data is provided. Deployment of PR networks is rapid and straightforward. A single omni-directional antenna per radio is used, thereby obviating the need for time-consuming antenna alignment. Once emplaced the network, through its microprocessors, is self-initializing and self-organizing. Finally, packet radios utilize spread spectrum RF waveforms which provide resistance to jamming, spoofing, detection and direction finding. This feature coupled to the distributed network management capability of PR networks make them redundant and highly survivable systems.[9]

The preceding discussion demonstrates that packet radio technology is highly responsive to the requirements for efficiently interconnecting tactical data systems. Care, however, must be taken not to confuse the microprocessors associated with the PR network with the functional computers and systems which the network serves. The packet radio microprocessors do not add computing capability to the PR network users' systems. Rather, they are control and management devices, integral components of the communications network, which allow the network to provide the near-real time, error-free connectivity the user requires.

DEVELOPMENT OF THE PACKET RADIO NETWORK CONCEPT

The concept of communicating by switching packets of information is clearly not new. In its simplest form, packet switching is the process which any postal service utilizes in day-to-day mail deliveries. Automating the switching is also not new and takes place in many of the commercial, fixed communications systems operating throughout the world today. What is a fairly recent development is the application of the packet switching concept to mobile, "smart" radio networks.

Experimentation with PR nets evolved with pioneering work done by the Defense Advanced Research Projects Agency (DARPA) in the field of advanced computer intercommunications studies. In support of this experimentation, DARPA has operated a working PR network in the San Francisco, California bay area since the late-1970s. In this test bed the agency has been able to establish the feasibility of data systems communications while on the move in hilly and built-up areas. DARPA has also verified in this test bed the feasibility of incorporating Electronic Counter-Countermeasures (ECCM) in the packet radios in order to insure the PR network's viability in tactical military applications.[10] Since 1978, Army personnel of the XVIIIth Airborne Corps at Fort Bragg, North Carolina have experimented with applying packet switching and PR networks to the day-to-day operations of the Corps, both in garrison and in field locations. Using a packet switched system labeled the Army Data Distribution System (ADDS), XVIIIth Airborne Corps

has automated several of its planning and reporting systems. To cite a few, weather forecasting, airlift planning and communications planning are now routinely accomplished and distributed at Fort Bragg using data obtained from packet switched systems. The PR Network concept has also successfully been demonstrated using experimental models deployed to field locations at Fort Bragg. Further testing awaits provision of a security device, now under development, to be added to the packet radio terminal. Personnel involved in these test bed activities report that ADDS works in response to users' needs — and the users like the concept and the capabilities the system provides.[11]

The most recent and most impressive demonstration of the use of packet radio technology in support of tactical military requirements took place at Fort Sill, Oklahoma during a test exercise known as HELBAT-8. The acronym derives from this test being the eight of a series of experiments conducted by the US Army Human Engineering Laboratory in the area of Battalion Artillery Testing. Conducted from September through November 1981, HELBAT-8 focused on future artillery operations and techniques with special attention paid to communications for command and control of such operations on a dynamic battlefield. Emphasis was placed on communications because of the very limited success obtained in HELBAT-7 (February 1979) while trying to operate the TACFIRE system over inventory VHF-FM radio nets. In HELBAT-8, eleven packet radios were utilized to form a PR Network over which TACFIRE computers and digital I/O devices could operate from dispersed Fort Sill field locations. The network included at least one unattended packet radio relay point and serviced users from the Forward Observer with his portable I/O device to the Battalion Fire Direction Center level with its

TACFIRE computer. The PR network, briefly described above, operated at an availability rate of better than 95% over the six week period of HELBAT-8. Although the packet radios were experimental models not-yet militarized or ruggedized, system performance was totally satisfactory and resulted in significant improvements in the response times of TACFIRE-controlled artillery.[12]

COMMAND AND CONTROL DATA COMMUNICATIONS FOR ARMY FORCES DEPLOYED AS PART OF A JOINT TASK FORCE

Over the past several years unexpected events which had the potential of threatening US interests in far-flung areas of the world have prompted the formation of the Rapid Deployment Joint Task Force (RDJTF). The newest of the US unified commands, the RDJTF's mission is to be prepared for world wide deployment, with focus on Southwest Asia (SWA), to act with military force, if necessary, to protect US interests. Although Army communications systems characteristics and requirements in the RDJTF scenario are basically the same as for operations in other areas, three aspects of the problem take on major significance. First, likely areas of deployment have comparatively little civilian communications infrastructure with which RDJTF requirements could be satisfied. Consequently, 100% reliance on military communications will be the accepted routine. Reliability and survivability of communications systems take on an added dimension of importance! Second, regardless of the size of Army force deployed, its operations in the RDJTF are expected to be characterized by high mobility, extremely fast reaction times, rapidly changing threats and dynamic mission assignments. Communications systems in such an environment must be capable of rapid set-up and tear-down and must have excellent ground mobility. Third, airlift resources will be at a premium. The luxury of extensive back-up systems will not be possible and communications systems will compete with other tactical gear for airlift. Consequently, communications systems must be

planned which are air-transportable and provide maximum capabilities within that constraint.[13]

This trio of considerations poses a significant problem for deployed Army forces, paticularly as the contingent grows in size in the deployment area. As previously described, many of the essential tactical command and control functions are either already computer-based or are moving rapidly in that direction. Out of operational necessity, Artillery and Air Defense Artillery units will require their TACFIRE and AN/TSQ-73 Missile Minder computers, respectively, in the deployment area. The same will be true for the maneuver control and intelligence systems as they evolve. Conversely, combat service support units will likely not be allowed to deploy computer-based data systems initially but will nevertheless require communications access to them in order to keep the force sustained. Therefore, the communications system deployed to support Army requirements must have the capability to provide access to computer-based processing power either in-country or at other distant locations. Figure 3. portrays a way this could be done using the packet radio network previously described, with the addition of one transportable component, a tactical satellite communications terminal. In this concept, in-country users #1, 2 or 3, for example, could obtain access to system computers A or B located in the CONUS be means of a gateway link G provided through satellite relay. Typical traffic on this data link would be such Army business as personnel status reporting, supply requisitioning actions, even airload planning support for follow-on airlift and for return to home stations at the conclusion of the RDJTF's mission. Data communications with CONUS locations could thus be provided to PR network users with a valid need, and restricted to other in-country subscribers.

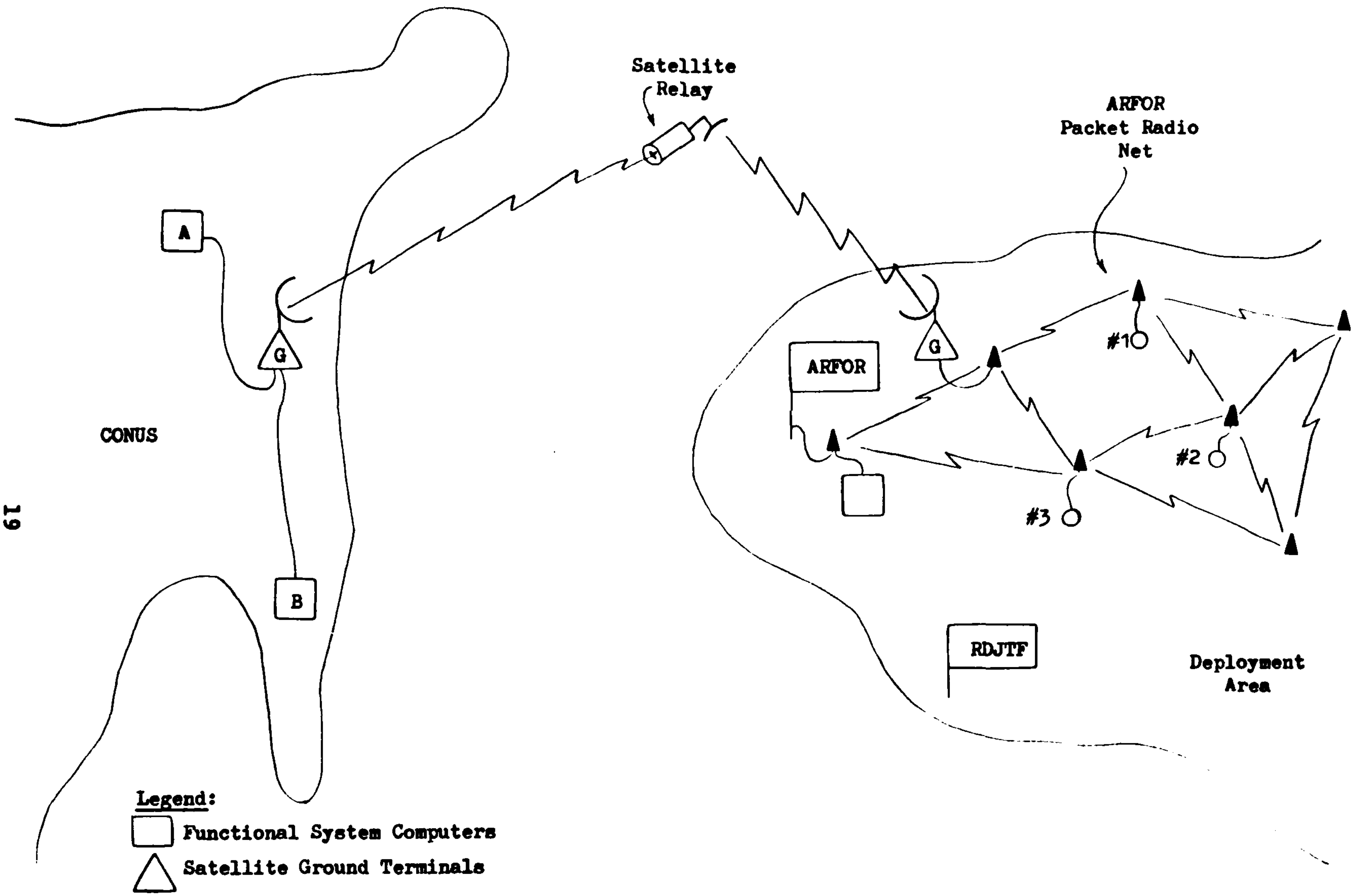

Figure 3. Tactical Data Communications Support for Army Forces in a Conceptual Joint Task Force Deployment

Simultaneously, the PR network in-country would provide its users the fast, mobile service deemed essential in the RDJTF scenario. The network would be able to expand as the Army force grows to the point where time and airlift became available to deploy the higher capacity tactical communications systems which would eventually be required for the larger force. Such a combined satellite/packet radio network would provide the near real-time information flow needed to shorten planning and implementation time, reduce the size and weight of the deployed force and guard at least some of the functional computer systems from enemy attack and environmental extremes in the deployment area.

CONCLUSION

In this paper we have reviewed in broad terms the dynamic, fluid characteristics which combat on the extended battlefield will exhibit. This paper has also focused on an arguably narrow but very crucial aspect of the communications support, that is, near-real time information exchange, which must be present on the extended battlefield <u>now</u> if we are to be successful. From the point of view of command and control communications, new Army doctrine calling for dynamic action on an extended battlefield presents serious difficulties. Quantum jumps in our capability in this area are required as a matter of urgency, for it has been shown repeatedly that current net radio equipment cannot handle the demand put on it for reliable, responsive support of battlefield data systems. In the five key functions of combat, i.e.,maneuver, fire support, intelligence, air defense and combat service support, systems automation developments have proceeded in the past without integration across all five functional areas. Communications, although critical to all five, has been treated as a separate functional area and new capabilities have been developed relatively independent of the combat functions that must be served.

The major point of this paper is that the technology is now at hand to field an integrated, i.e., processor controlled, radio capability to provide the near real-time network connectivity of data systems needed on the extended battlefield. We must capitalize on the tremendous

advances in microprocessors which provide so much reliable computing power in such small packages. Integrating this capability into our radio nets allows the technique of time sharing, i.e., packet switching, to be implemented. It is that capability and that technique which will allow us to reduce equipment and manpower requirements, provide the tactical data systems connectivity required and generally keep up with operations on the extended battlefield, be they in Europe or as a part of the RDJTF. Hopefully, we will be able to avoid the devastating condition of "tenuous" communications predicted for the contemporary battlefield in FM 100-5.[14]

ENDNOTES

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